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Vol. XLVII No. 1217

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SOME DEVELOPMENTS IN THE CHEMICAL INDUSTRIES AS A RESULT OF WAR CONDITIONS[1]

IN these passing days every branch of scientific activity has many striking illustrations of the fact that its fund of knowledge and experience is being vigorously drawn upon to meet the pressing needs of the hour. Where so many sciences are making notable war records it may seem invidious to select any single one for review. But my own personal apology must be that I have not the ability and certainly a single evening has not enough hours for presenting the activities and the accomplishments of the entire field of science. While, therefore, we are proposing to discuss matters having a more or less chemical tinge it should be emphasized at the outset that we are not unmindful of the wonderful service in manifold ways resulting from the activities of the physicist, the engineer, the geollogist, the bacteriologist and botanist, the psychologist, the pathologist and sanitarian: All these and many other workers in related branches of science have achieved results which are quite as fundamentally important as anything the chemist may have to offer.

A further word of explanation or possibly of warning may also be in order. The field of the chemist is so wide and his activities touch so many interests that sometimes he must be not altogether certain himself when he is treading the paths that lie outside of his own borders. Indeed he must appear occasionally, in the mind of other people, at least, to have adopted as his own the

[1] Annual address delivered before the Society of Sigma Xi, University of Iowa, February 13, 1918.

line from Kipling, which runs, "Yours is the earth, and everything that's in it." This must be the explanation, therefore, if we seem to discuss some topics where the chemical connection is but dimly discernible or possibly lost entirely.

In the first place then, let us discuss the fuel problem, that is to say coal:

It has seemed to take a war situation to shake us into a realization of the fundamental and elementary fact that coal transportation must be evenly distributed throughout the year and not left to the congested conditions of the winter months. We talk about a fuel famine due to car-shortage. It is not a shortage of coal cars that troubles us—but rather a shortage of the thinking process in connection therewith. What indeed is a car shortage? You say it is the opposite of having cars enough. Now if we mean, by an adequate railway equipment, enough cars to serve the mines and move the coal to accord with the abnormal demand of the winter months, no railroad in this country now has, or ever can afford to have, such an equipment. Mr. C. G. Hall in 1914, while Secretary of the International Railway Fuel Association made an estimate to the effect that if we were to take only five of the leading coal-moving roads of Illinois and Indiana and calculate the additional equipment they would need in order to fully serve the mines and meet the current consumption of the winter months, these five roads would require 250 additional locomotives and 30,000 cars representing, together with the necessary additional trackage and yard equipment, an expenditure of approximately $75,000,000. This would represent for this small group of railways alone, a fixed charge in the way of interest, amounting to nearly $4,000,000 per annum, with the extra equipment standing idle and nonproductive for eight months of the year. Indeed, he goes further and estimates that the railways of the country already have in service coal cars over and above the number that would be necessary if the same tonnage could be handled at an even rate throughout the year, and such excess equipment represents an investment, even under existing conditions, of over $105,000,000.

But all of these features were in evidence before the present war. They still exist in even more pronounced degree, with a number of added features. We talk of eating less wheat so that our Allies may have more bread, but we ought also to have put in our coal supplies last August so that in January the war necessities and the fuel needs of our Allies might have a better chance at the coal pile. I am just in receipt of a letter from one of my colleagues who left the laboratory about four months ago. It was written in Paris and I quote a sentence or two: "We have plenty to eat but the amount of radiation allowed is very small. If I had as much coal here as I had in my cellar at home I would be arrested for hoarding. Coal is actually $70.00 per ton." The point of the whole matter is this: We must learn the art of storing coal. It is not the railroads alone that are concerned. The miners and coal operators are equally involved. Under the present system the mines are operated on an average about 200 days in the year. Such a system must have a demoralizing effect upon labor, so that many serious social as well as economic and financial questions are involved.

And where now does the chemist come in? I was passing through a neighboring town about the middle of last September and saw along the railway tracks a coal pile of about 30,000 tons, burning too fiercely to be quenched or moved and as a result the entire lot was a total loss. Other similar fires have been reported, among them the

firing of a pile of 100,000 tons at Superior, Wisconsin.

A number of chemists and engineers have been quite diligently at work for a number of years on this problem of the storage of coal, and the interesting point is that these results are now available in such form as to furnish a practical contribution to this very important problem and it is certainly an opportune time for this work to have been completed. The summary of it all seems to be:

First: That coal can be stored in large masses with a very fair degree of safety from spontaneous combustion, and

Second: That the loss of heat values due to weathering or other deterioration processes is practically negligible.

As confirmatory at least of the first of these conclusions the case may be cited of a large power and lighting concern which for some time has been putting in practise the principles involved in the proper storage of coal and indeed had a very considerable stock on hand. During the recent freight embargo due to weather conditions this company was able to continue its service without interruption by drawing upon its reserve supplies. Only an occasional car of coal was received from the mines by this concern for 30 days immediately following the 5th day of January, 1918. What this meant to the operating end of the system and the community which it served may be realized when it is known that the fuel demand of their boilers amounted to from 6,000 to 7,000 tons per day. Here in fact was a storage supply that could be drawn upon and was drawn upon to the extent of over 200,000 tons. The practicability of storing western bituminous coals was thus strikingly demonstrated. The chemists have worked out the fundamental principles involved. It is up to the engineers to apply them. The storage of coal having been shown to be possible it at once becomes an industrial as well as a war measure of very great importance.

Not greatly distant from the coal question is the subject of coke. We can not win wars without iron and we can not make iron without coke. Previous to 1914 the by-product method of coke manufacture was making steady but slow gains upon the almost criminally wasteful process as carried out in the bee-hive oven. Approximately 75 per cent. of all the coke produced in the United States came from bee-hive ovens. For the current year, 1918, it is estimated that the by-product ovens will produce 50 per cent. of the total yield. Something can be understood as to the magnitude of this change when it is recalled that an equipment of bee-hive ovens can be built and put into commission for a few thousand dollars while for a by-product equipment the cost is hardly less than from $3,000,000 to $5,000,000. It is doubtful if anything has occurred during the last four years that will more profoundly affect our industrial activities than this revolution in our coking process. In the old bee-hive oven all of the volatile constituents of the coal were burnt and lost unless we count the heat produced as having some value in the formation of the coke. But that procedure was like burning up five dollars' worth of high-grade material to produce five cents' worth of low-grade heat. The only product of the bee-hive oven was coke. In the by-product oven the coke has almost come to be the by-product while the volatile or liquid material might be looked upon as the item of chief interest. For illustrating a point a little further along it will be worth while at this point to mention a few more important of these constituents. We will not stop to name them all, since potentially at any rate, their number would be about 7,000.

There is, then, gas, for the city mains, ammonia for fertilizers and munitions, benzol for colors, toluol for explosives, phenol, being just plain carbolic acid, for antiseptics, explosives and phonograph records, creosote oils for the wood preserver, anthracene for more colors and then just plain tar. This enumeration brings us directly to a discussion of the coal-tar dye industry.

Three years ago we were being warned that the foreign dyes would soon be exhausted, that none were made in America, that the men would have to wear white socks and neckties to match, and that gaily colored ribbons and dress patterns for the ladies would have to be forgotten. All of which delectable information was accompanied by the query, "What is the matter with the American chemist?" A number of thoroughly well informed among the brethern made reply which in substance set forth the fact that the American chemist was all right and just as competent as any other chemist in the matter of dye stuffs, but with much emphasis, they set forth the very pertinent fact that as a manufacturing proposition it required large capital. That the business was interrelated and interwoven with so many subsidiary lines that all must be built together in order that any one feature could succeed. The complete circle of establishments and processes needful for embarking in the industry is well suggested in the short list of by-products already given. Now they estimated that on the most conservative basis, the capital needed to start the dye industry could not be less than ten million dollars and what was more, the experience of a former attempt to establish the industry in this country resulted in almost complete industrial wreckage of the business caused by the dumping process from German factories. A financial record of this sort made the prospect of interesting large capital impossible without protection. Because there was at the time a total lack of protective legislation it was argued that the same disastrous experiences would result, so the chemist passed on the question and referred it to the capitalist and Congress with emphasis on the fact that it would take both legislation and money to establish an American dye industry. And so the matter rested quiescent and was almost forgotten.

A few days ago I hapened to be passing through one of the largest department stores in Chicago and indeed of the world. My route, purely by accident of course, took me past the dress goods and ribbon counters and also through the division where neckties and socks were displayed. The profusion of colors on every hand recalled quite vividly some of the predictions of three years previous and I made mental note of the confirmation of numerous facts, which have been coming to the surface, relating to the development of the dye industry in this country. These facts are doubtless familiar enough to the chemists, but so quietly has the work gone along and so little has been said about it outside of chemical circles that a brief reference may not be amiss at this time.

Four years ago the firms in this country engaged in the manufacture of dyes and intermediates or accessory substances numbered all told about six, mostly in fact importation houses. Only two or three of these were of even moderate size or had any great amount of capital invested. At the present time there are not six nor sixty nor twice sixty, but 130 such corporations actively engaged in the business. The capitalization of these concerns, previous to about October 1 of last year, was stated to be approximately $150,000,000. Since that date the Dupont Company has announced its intention of entering upon the manu-

facture of dyes and associated chemicals. The especial amount of capital to be set aside for this purpose does not seem to be stated. It is perhaps sufficient to know however, that the capitalization of the Dupont Company amounts to $240,000,000. As for legislation, that matter has been fairly well attended to, so that piracy and financial submarine warfare would seem to be eliminated.

And now what about the chemical part of it? Previous to 1914 the importation of dyestuffs into this country amounted to a little over 10 millions dollars per year. The home production was insignificant even for our own use and the exportations were conspicuous by their absence. During the year 1917 we had caught up with the production of dyestuff to such an extent that the output was sufficient to meet all home demands with possibly one exception, namely, the manufacture of indigo blue which had been so largely contracted for to meet the needs of the United States Navy that there was as yet no surplus for the general trade. This does not mean that all of the possible 1,000 formulas representing that number of different dyes and which were available before the war are now made in this country. It does mean, however, that the possible 100 dyes called for by the everyday work of the dyer and meeting substantially all of his needs are at hand.

Such an accomplishment would not have been thought possible even by the wildest dreamer two and a half years ago and in itself would be quite sufficient cause for profound congratulation to all concerned, chemists, capitalists, the ribbon counters and the ladies, but that is only half and less than half the story. In addition to being able to supply our own needs the exportations to other countries for the first ten months of 1917 amounted to a total of $12,500,000 and if the exports for December last are an index for the current year, the dyestuffs sent abroad from this country in 1918 will reach a total value of over $16,000,000.

Permit me further in this connection, to paraphrase an old exclamation, "That beats the Dutch!" by saying "This beats the British," because early in 1916 it was announced that there had been formed in England and British Dye-stuff Syndicate, backed financially to the extent of about $15,000,000 by the manufacturers of dyes, the textile industries and the government, with the avowed purpose of making themselves self-contained and independent of foreign supplies. Of course the English people are tremendously busy with other things and there is no thought whatever of reflecting on their ability to accomplish what they set out to do in this *or any other undertaking*, but it is interesting to know that our largest customer last year was Great Britain, whose purchases of dyes exceeded a value of $3,000,000.

Before leaving the subject of dyes, it may not be out of place to mention a circumstance, involving, perhaps, too much of detail or possibly of personal interest to be included in this discussion. However this is the item: About eighteen months ago a chemical graduate from one of these land-grant colleges which we now dignify with the title of state universities, one of my own students in fact, completed his investigations in a government laboratory upon the possibilities of a dye which he had developed from the wood of the osage orange. The results of this work are now almost everywhere in evidence, because of the utilization of this dye as the coloring matter for the khaki uniform cloth of the American army. I wonder if his acquaintance with the osage orange does not result directly from its introduction, throughout the upper Mississippi Valley, some fifty

years ago by Professor Jonathan B. Turner, the father of these same state universities, the educational prophet of the generation preceding our own and the personal friend of Abraham Lincoln, the weight of whose influence and whose signature to the Morrill bill in 1862 made possible the founding of these universities, may we not say, of the common people.

Intimately associated with the coal-tar dyes is the subject of munitions. Some months ago in conversation with the chief chemist for one of the largest munition plants of the country, the question was asked if he was able to keep reasonably busy these days, at least so that Satan could not readily find some mischief still for his idle hands to do. His reply was significant and made without note or comment. It did not need any. He said our total output of explosives at the present time amounts to a million pounds per day. Of course a very large part of this output is used in mining and blasting, but the aggregate of high explosives, which before the war was insignificant, now approximates something over two billion pounds per year.

The substances from which the three main types of explosives are made are glycerine, phenol and toluol, but the greatest of these is toluol. Where are we to get the toluol? The question has been partly answered in the great increase of by-product coke ovens. But if twenty million tons of coke are made in these ovens during the current year and the yield of toluol is one half gallon per ton then we only have in sight from this source about ten million gallons of toluol, only about one quarter of the amount required for making the munitions needed for our own army. But the call has already gone out for "toluol and more toluol." The first measure to meet the demand, and which is now being inaugurated, is the stripping of city gas of this material. It can be spared without any great detriment to the gas and amounts to approximately .04 of a gallon per each 1,000 feet of gas. Ten of the largest cities of the country where this process is to be first installed are estimated to yield approximately an additional 10,000,000 gallons. However, the problem is really in process of solution. It is an extremely vital question, and is causing anxiety in some quarters but it will doubtless be met and answered in good time.

It may be interesting to note in passing that for each gallon of toluol, there is produced from five to six gallons of benzol. Even now this material is being produced in such quantities that the usual channels for its use are more than satisfied. This primarily has a bearing on the dye industry since it forms the starting point for the largest part of the dyes. But benzol has now come to be the starting point for the manufacture of carbolic acid and carbolic acid, or phenol, is the starting point for picric acid, another explosive, and also for the manufacture of Bakelite, which has almost completely replaced gutta percha in electrical appliances, and then, coming nearer home, it is Bakelite which furnishes the material for the manufacture of phonographic records. One more possible adaptation of benzol is of interest. It is miscible in all proportions with alcohol and when so mixed furnishes a motor spirit in some respects superior to gasoline. Indeed a well-authenticated report seems to indicate that about 70 per cent. of the motor spirit used in Germany at the present time is made up of this material. These various items will serve at least to show the interrelated character of the very large and important group of interests which are associated with and grow out of the coking process. But time would fail me

if I attempted a mere enumeration of all the interesting developments connected with the coking of coal.

As for gasoline, the output last year exceeded two and one half billion gallons. But that is not enough. The current year will probably see this amount increased by possibly 10 per cent., through the extension of the stripping of the condensable material from natural gas and from the extension of the cracking process, especially the method now developed to such a practical stage by Dr. Burton, of the Standard Oil Company.

And what about potash? We are told that the production for 1916 was ten times what it was for 1915, but that does not mean much, for we made less than 1,000 tons in 1915. The output for the current year will doubtless exceed 40,000 tons, but even that loses much of its significance when we remember that our previous importations from Germany amounted to about 275,000 tons per year. But recent, almost monthly developments are exceedingly interesting and encouraging. There is first the brines, especially of western Nebraska and southern and southeastern California. This is at present by far the largest source. Then come the Kelps of the Pacific coast, still in the developing stage but moving rapidly and encouragingly—and then come the alunite deposits of Utah, a real producing proposition, but relatively as yet on a limited scale. We are just beginning to get glimpses of the possibilities from cement furnaces, from the green sand of the Eastern States and from the feldspars in widely distributed localities. At the present rate this problem seems in a fair way of solution.

And meantime what of the industries using potash, for example in glass manufacture? Soon after the outbreak of the war, the chief chemist for one of the largest glassmakers of the country was asked what he was going to do for potash. His reply was that he had for some years urged upon his firm the advisability of experimenting with soda as a substitute for potash, but they insisted upon "letting well enough alone." But now since they were obliged to try it by force of circumstances they were so well pleased with the results that they would not return to the use of potash even should it become again available.

Similarly the gold miners were distressed to know where their supply of potassium cyanide was to come from when importations of potash salts ceased. At the Secoud Chemical Exposition at New York in 1916 one of the large chemical concerns had on exhibition some fine-looking sodium cyanide. The question was asked how it was working out. The reply was that it was proving advantageous over the potassium cyanide in numerous ways. It had a higher percentage of the active principle per unit of weight, was cheaper to manufacture and they would not return to the use of potassium salt even should the supply of potash again become available.

Again, take the crucible situation. The manufacture of graphite crucibles is an exceedingly important one to practically all of the metallurgical interests, from steel to gold. The clay used in their manufacture must be high grade and possessed of special properties. It all came from a particular locality in Germany. The stock in hand of that material lasted about a year. Meanwhile a vigorous search for substitutes had been going on. The first of this new material was put out about two years ago, the shipments of these crucibles bearing a tag which constituted a sort of apology, stating that the supply of foreign clays had become exhausted and asking for some care and some indulgence if the

quality of the new crucibles was found to be not quite equal to the old.

I have myself had occasion to use these new crucibles under quite as exacting conditions and certainly under quite as high and probably higher temperatures than those commonly employed. My conclusion is that the manufacturers should now send out these wares with a new label, which would be in effect an apology for the first apology and say, "These crucibles are made in America, of American clays and we take pleasure in guaranteeing their superiority over anything formerly manufactured from foreign material."

Then there is optical glass. It all came from Germany. In their own experiments in attempting to develop a high-grade optical glass the Germans published to the world the results of their experiments for about ten years. When they began to get valuable results the government stepped in and there has been an impressive silence for the years following. At least no one outside of Jena seemed to know how to do it. The French and English each had a single factory which was making a good glass but all of their output was needed at home and was at once commandeered. Here then was an immediate and imperative need, for both the navy and army must have range finders, field glasses, cameras and telescopes without number. The problem was taken up by the government laboratories and by scientific calculations and deductions coupled with skillful experimentation they are now able after ten months to produce not only a better but a greater variety of optical glass than the Germans had been able to produce in ten years.

And now just a word about nitrates. When we note the mere names of the explosives manufactured it is apparent that they are all nitration products and that nitric acid is an essential in the making of every one of them: Nitroglycerine, Nitrocellulose, trinitrotoluol, trinitrophenol, ammonium nitrate and even the niter in the old style of black powder confirms this fact. Nature, it seems, has been very partial in her distribution of nitrates in quantities to be at all worth while, Chile alone being the fortunate country. But with four fifths of the air nitrogen, one ninth of the water hydrogen and all the rest of both being oxygen, we at least can be said to have the raw material in sight, or perhaps better, at our very doors, at all times. No wonder the question is being rather nervously asked, "What are we doing to insure an adequate supply of nitrates?"

As a protective measure, while we are doing our thinking the government is spending $35,000,000 on reserve supplies from Chile, but already Professor Bucher, of Brown University, and the chemists of the General Chemical Company each along separate lines has developed successful processes for the manufacture of ammonia, the present most effective starting point for the manufacture of nitrates and nitric acid, so that already work has begun on the establishment of a plant at Sheffield, Alabama, capable of producing 60,000 pounds of ammonia per day. Germany, of course, has been doing her own developing, for it is assumed that she did not have a stored-up supply of Chile saltpeter sufficient for more than about a year, but it is now evident that we will out-nature nature and incidentally out-Germany Germany since we have in sight for the coming year the certainty of meeting all of our needs in this line.

But almost everything chemical requires sulfuric acid. Indeed this acid is said to be the index finger which points out the chemical activity of a country. The finger for 1917 indicated that the manufacture of sulfuric acid of all strengths for 1917

amounted to five and one half million tons, an increase over 1916 of over 600,000 tons. Now recall that all of the nitration processes above referred to in the methods of manufacture of explosives employ nitric acid primarily and also sulfuric acid as an accessory to the deed, as the lawyers might say, and the further fact that a total of over two billion pounds are made per year at the present time. This is nearly 300 times the output in 1913 and over half of it is exported. Now the question is, "What sort of apparatus can stand up in use under the action of these acids, especially in the manufacture of these enormous quantities of explosives?" The answer has been worked out and can be fairly well read in the advertisements in the chemical journals of "Duriron," "Tantiron," "Buflocast" and so forth. Five years ago we were familiar with what by comparison might be termed toy samples of apparatus made from this material. To-day the magnitude of the apparatus made takes on really huge proportions. One might almost say that some of them would house a coach and four. We can now understand, I think, a remark made at the second Exhibition of the Chemical Industries held in New York in 1916. A professor in one of our oldest universities in passing by the various exhibits, stopped in front of the display showing the various forms of Duriron. After a moment's pause he remarked impressively, "Ah! it is this which has saved England."

And so we might go on almost ad infinitum. But the time would fail me to tell of magnesite, an essential for high temperature furnace linings, formerly all imported from Austria and Hungary, now produced in California and Washington more than enough for our own needs. Of rare and unusual chemicals such as dimethylglyoxene, heretofore only "made in Germany," an indispensable reagent for analytical work with nickel steels, of photographic materials, of remedial agents and synthetic drugs such as novocaine, a local anesthetic of great value: of thermometers and graduated ware, of glassware and porcelain equal to the best of former importations. The chemists of the country seem to have been awake at the switch and I think we must agree that they have been singularly effective in their work.

I would like to discuss for a moment some of the underlying causes which I believe have been of fundamental importance and largely responsible for this effectiveness. The mere enumeration of the above items is informational and may even be interesting, at least to the chemists, but to my mind it should serve an additional purpose of even greater importance. It seems to me therefore that we may well devote the few minutes remaining to pointing a moral and making the attempt at least of furnishing a little adornment to the tale.

The great underlying fact which must be evident to any one who digs but a little way below the surface in seeking an explanation for the success of the chemists is this: The most pronounced advancements of the art, the real achievements, that have, with such seeming readiness and almost as if by calculation promoted these strikingly successful results have been brought about by men of thorough training in the purely scientific principles of their art. Here in the universities of the country has been going on in a quiet way for fifteen or twenty years past a type of preparedness which I believe may be worth our while to study.

The method of training the chemist is almost uniformly on the principle that if you are going to make a scientist in the field of chemistry, then surely he must know the science of chemistry and if you

are going to make an applied scientist in the same field, he must still know the science before he can have anything to apply. It is not possible, at least it is not possible any more, to make a rule-of-thumb chemist and turn him out to practise what in his case could only be a black art.

You say that chemistry lends itself especially to this method of procedure, but it is not different in this respect from the other sciences. There is no greater truth in evidence in all of the sciences than this, that the men who are accomplishing things are the men who have had the training in the theoretical as their real preparation for the practical ends which they are to accomplish. The state universities were founded immediately at the close of the Civil War almost before the noise of battle had died away. It is not strange that the provision was made that attention should be given to military instruction and so that sort of preparedness has been going on through all the years since. Nor am I belittling its value, for I believe in it thoroughly, but in its relation to the real preparedness of the country the value of that work shrinks almost to the zero point in comparison with the quiet, undemonstrative but effective training in the sciences that has been going on in these same universities. We have heard not infrequently and indeed seen it demonstrated that you can make a soldier and an army if you have to in two years, but it takes twenty years to make a scientist and there is no fact that stands more clearly demonstrated to-day than that for great emergencies you must have a vast number of scientifically trained men and there is not a little satisfaction in the further fact that they are equally good material to have around either in peace or in war.

If our own system of education in the sciences and their close linking with the industries is not sufficiently convincing, turn for a moment to Great Britain. At the opening of the war their eyes were suddenly and most distressingly opened to the opposite aspect of the picture. They had been sailing the seas and trading in goods and had left the bulwark of their technical industries, their men trained in the sciences, altogether too largely to wear also the label, "made in Germany." This is not my criticism. To the credit of the Britisher be it said that when he sees the truth he is not afraid to speak it. In this matter he has been his own relentless critic. Read some of his conclusions: H. E. Armstrong in an address before the British Association, August 1914 (*Nature,* 94, p. 213) refers to Huxley, who in 1861 pronounced these prophetic words:

> Physical science, its methods, its problems and its difficulties will meet the poorest boy at every turn and yet we educate him in such a manner that he shall enter the world as ignorant of the existence of the methods and facts of science as the day he was born. The modern world is full of artillery, and we turn our children out to do battle in it, equipped with the sword of an ancient gladiator. Posterity will cry shame on us if we do not remedy this deplorable state of things. Nay, if we live twenty years longer, our own consciences will cry shame on us.

Professor Armstrong proceeds,

> Now after more than fifty years, not twenty merely, we still go naked and unashamed of our ignorances; seemingly there is no conscience within us to cry shame on us. I have no hesitation in saying that we have done but little through education to remedy the conditions of public ignorance which Huxley deplored. In point of fact he altogether underrated the power of the forces of ignorance and indifference; he failed to foresee that these were likely to grow rather than fall into abeyance.

Sir Ronald Ross, in *Nature* for 1914, p. 366, says this:

> The war now raging will at least demonstrate one thing to humanity—that in wars at least the scientific attitude, the careful investigation of details, the preliminary preparation, and the well

thought-out procedure bring success, where the absence of these lead only to disaster.

You will remember that an attempt to remedy this situation resulted in the organization of an advisory board composed mainly of eminent scientific Englishmen to cooperate with a committee of the Privy Council. An editorial in *Nature* for 1915 says of this scheme:

> By its inception and publication the government acknowledges and proclaims its appreciation of the work of science, and by this acknowledgment alone gives scientific workers that encouragement and prestige in the eyes of the country which has too long been withheld.

May we not venture to note that in our own land this propaganda on behalf of science has been active and indeed effective through the work of our universities for so many years that we have almost forgotten the early struggles of the advocates of this type of educational work.

I have said that it takes twenty years to make a scientist. We often hear it said that graduation, after four years of study, is only the commencement of things. This is nowhere more true than in the case of the sciences. Real effective training in these lines does not come and can not come except as a result of application and toil and devotion and the intensive training which accompanies research work. See how wise the great industries are in this respect. How their research departments have grown in number and what a corps of thoroughly trained and theoretically trained men they have put in charge. And not the pity of it but the danger of it is that they are drawing upon our universities for their best and strongest men to direct and develop their work. How long and to what extent will it be wise to allow these inroads to be made is a serious question, which perhaps can wait awhile for settlement. The immediate and pressing obligation now is to continue without let or hindrance in the task of training men even more profoundly and thoroughly in the fundamental theories of the various sciences. To the universities, to the Sigma Xi and to scientists everywhere this situation ought to come as a call to the colors. Yours is not the glamor or the pomp and circumstance of war but you have the goods, and your quiet and steadfast continuance in the work of scientific development has in it the very essence of patriotism. Your satisfaction and compensation must come from the witnessing on every hand and from every line of scientific endeavor to the inestimable value and far-reaching influence that flows from your work.

The industrial world to-day not only welcomes but demands this type of trained men. Their reception to-day as they leave the universities is in marked contrast to what it was twenty-five years ago. I recall an editorial in one of our metropolitan newspapers, written just at the time of year, a long time ago it seems now, when the universities were sending forth their quota of graduates. Their inexperience and unadaptableness to this worldly world was expanded and more or less flippantly dwelt upon under the caption, "What can they do?" In any review of what this type of the genus homo is doing to-day in medicine, in surgery, in sanitation, in food products and food production, as seers, as prophets, as wizards, if you please in unraveling and setting in order and at our disposal the material things of the universe, granted as I have already said that they be given the necessary opportunity for aftergrowth in lines of study and research —there seems to come an echo from that old-time newspaper dissertation which calls for another article in quite a different vein and indeed whose purpose would be to set out in their proper perspective the work of these same university products. The

proper and fitting caption of such a dissertation, it seems to me, would be "What can they not do?"

Fellow workers, companions in research, I profoundly believe that research must mean a different thing after we are through with these passing days of frightfulness. It was counted upon by Germany as her greatest asset. It must prove to be America's bulwark of defense. It has been sufficient in the past that your impulse has been the search for truth for truth's sake. It is inevitable that that impulse must now be raised to an inspiration with a very passion for truth for humanity's sake. As you have worked unwittingly, but none the less effectively for preparedness, so may it be your part to work unremittingly and with equal effectiveness towards the building again of the temples of peace, to turning the dark clouds inside out and contributing to the greater successes of a better day.

S. W. Parr

University of Illinois

THE NEW HOPKINS MARINE STATION OF STANFORD UNIVERSITY

The project of the development of a marine biological laboratory in connection with Leland Stanford Junior University owes to its origin to Professor Charles Henry Gilbert and Professor Oliver Peebles Jenkins. Recognizing the value and importance of such a foundation, they set actively to work during the first year (1891) of the University to secure its realization. After a careful examination of various sites along the coast, Pacific Grove, upon the southern side of Monterey Bay, was selected as combining the most desirable features. Through the generous cooperation of the Pacific Improvement Company a suitable site and a sum of money sufficient to erect the first building was donated. A plain two-story frame structure, twenty-five by sixty feet in ground dimensions was erected on Point Aulon, a low rocky headland, and the first session of the new laboratory was held during the summer of 1892. In recognition of the active interest and liberality of Mr. Timothy Hopkins the station was named the Hopkins Seaside Laboratory. Funds for the purchase of books and equipment were provided by him from time to time, and in the following year he erected a second building. The two buildings contained four general laboratories, a lecture room, seventeen private rooms, and a large concrete basement for special physiological work. The salt-water piping for the aquaria in the second building was constructed of pure block tin throughout, with hard-rubber stopcocks.

During the first twenty-five years of its existence the laboratory while nominally a part of the university and freely using its library and apparatus, was dependent for its upkeep and extension chiefly upon student fees and private gifts, the latter mainly through the constant sympathetic interest of Mr. Hopkins. Despite these limitations it offered its facilities to many investigators and students during that period, and contributed materially to the solution of biological problems on the Pacific coast.

With the passing years it became increasingly evident that the site upon Point Aulon was inadequate to the needs of the laboratory. In 1916, through the efforts of President Wilbur and the Board of Trustees, a new location was secured nearly five acres in extent and comprising the main portion of Almeja or Mussel Point, situated a half mile eastward of the old site. This point will be recalled by former visitors to the Seaside Laboratory as that upon which the fishermen of the picturesque "Chinatown" used to dry their large catch of squids. Chinatown disappeared in a blaze about fourteen years ago, and was never rebuilt. The new situation insures complete control of the coast line of the point, including an excellent sheltered landing place and harbor for boats of considerable size (used in the old days by Chinese fishermen).

Close to this cove the first building of the new station was erected during 1917. It is of reinforced concrete construction approxi-

mately forty-one by eighty-four feet over all and of a height of three stories. On the ground floor is a physiological laboratory, twenty-three by thirty-nine feet, containing a large floor aquarium of cement, six by fourteen feet, a private laboratory, ten by eleven feet, also a concrete-floored room twenty-three by thirty-nine feet for sorting collections, and for the storage of boats, collecting apparatus, etc. There are, besides, a large storeroom, furnace room, janitor's room, photographic dark room and men's lavatory.

The second floor, into which the main entrance opens, is devoted to the three large general laboratories, two of them approximately twenty-three by thirty-nine feet, the third twenty by thirty-six feet, and accommodating each twenty-eight students. Two private laboratories for instructors are also provided on this floor.

The third floor contains a large library with a generous fireplace, an adjoining room for records, an advanced laboratory, twenty by twenty-two feet, six commodious private laboratories for investigators, and a rest room for women. Fresh and salt water are supplied to each laboratory, the sea water being pumped to a concrete tank on the roof, whence it is distributed to the various double-decked, cement aquarium tables. Heating is provided by a hot-air system, electric lights are installed, and gas soon will be. From the third floor a stairway gives access to the flat, parapeted roof, where open air aquaria may be set up as needed. There are thus five laboratories available for classes and nine private laboratories for investigators. The private rooms have much the same equipment as that used at the new Woods Hole Marine Biological Laboratory.

The plans for the Station are very largely the work of Professor Frank Mace McFarland, of the Department of Anatomy, in conference with Professor Charles Henry Gilbert, of the Department of Zoology.

In fitting recognition of the aid rendered by Mr. Timothy Hopkins during the whole life of the Station, the Board of Trustees of the university named the new institution on October 26, 1917, the "Hopkins Marine Station of Stanford University."

The Hopkins Marine Station fulfills a twofold function: first it furnishes under exceptional natural advantages elementary and advanced instruction in biology, second, it provides for research work. Beginning June 15, 1918, the Station will be open the entire year, the Director being in residence. Investigators and special students can be accommodated at any time. Regular classes are scheduled for the spring (April 1 to June 18) and summer (June 19 to August 30) quarters only. As formerly, the use of Station facilities is tendered to investigators free of charge; students are required to pay a small fee.

The Station is an integral part of Stanford University, controlled by the board of trustees, the president, and the academic council in the same manner as other departments of the university. In addition there is a small committee of the faculty exercising advisory and to a certain extent executive functions. The staff consists of the director and those members of the faculty who offer regular courses of instruction at the station.

The extraordinarily rich fauna and flora of the Monterey Bay region offer exceptional opportunities to investigator and beginning student alike. There are a surprisingly large number of marine animals and plants readily accessible. The student of land forms will encounter a varied assemblage of species, since there are very few regions of equal extent which offer such a curious combination of widely diverse ecological formations. There are probably a greater number of endemic plants than in any other similar continental region. Investigators in the fields of general experimental work, taxonomy, anatomy and embryology will find a wealth of material to chose from, while those concerned with a study of animals or plants from the special standpoint of their "marineness" will naturally be exceptionally favored.

During the summer quarter (June 19 to August 30, 1918) courses will be offered as follows: General Zoology, by Professor E. C. Starks; Economic Zoology (Marine Inverte-

brates) and Invertebrate Embryology, by Professor Harold Heath; General Physiology and Research in Physiology, by Professors E. G. Martin and F. W. Weymouth; The Algae and an advanced course in Botanical Survey, by Mr. J. I. W. McMurphy.

President Wilbur has appointed W. K. Fisher, of the Department of Zoology, director of the station.

W. K. Fisher

SCIENTIFIC EVENTS

THE BOMBARDMENT OF PARIS BY LONG-RANGE GUNS

Professor G. Greenhill writes in *Nature* that the Jubilee long-range artillery experiments of thirty years ago were considered the *ne plus ultra* by the British authorities, and were stopped at that, as they were declared of no military value. But the Germans are said to have watched the experiments with great interest, and to have carried the idea forward until it has culminated to-day in his latest achievement in artillery of a gun to fire 75 miles and bombard Paris from the frontier. Professor Greenhill writes:

> From a measurement of the fragments of a shell a caliber is inferred of 240 mm., practically the same as the 9.2 inch of our Jubilee gun, which, firing a shell weighing 380 pounds at elevation 40°, with a muzzle velocity nearly 2,400 feet per second, gave a range of 22,000 yards—say, 12 miles. This was much greater than generally anticipated, but in close agreement with the previous calculations of Lieutenant Wolley Dod, R.A., who had allowed carefully for the tenuity of the air while the shot was flying for the most part two or three miles high.
>
> The German shell is likely to be made much heavier and very nearly a solid shot, better by its weight to overcome air resistance, the chief factor to be consdered in the problem of the trajectory. If it was not for this air resistance a range of 75 miles with 45° elevation could be reached, on the old parabolic theory of Galileo, with so moderate a velocity as $V = \surd(gR) = 3{,}200$ feet per second, with $g = 32.2$, $R = 75 \times 5{,}280$; in a time of flight of about $2\frac{1}{2}$ minutes, an average speed over the ground of 30 miles per minute.
>
> A velocity of 3,200 feet per second was obtained by Sir Andrew Noble in his experiments at Newcastle about twenty years ago with a 6-inch 100-caliber gun, with a charge of $27\frac{1}{2}$ pounds of cordite and a shot of unspecified weight, so it may have been the usual 100 pound or perhaps an aluminium shot of half the weight.
>
> Double velocity is usually assumed to carry twice as far; at this rate the velocity of our gun would require to be raised from 2,400 feet to about 6,000 feet per second to increase the range from 12 to 75 miles; such a high velocity must be ruled out as unattainable with the material at our disposal.
>
> But in this range of 75 miles the German shot would reach a height of more than 18 miles and would be traveling for the most part in air so thin as to be practically a vacuum, and little resistance would be experienced.
>
> So it is possible a much lower velocity has been found ample, with the gun elevated more than 45°, for the shot to clear quickly the dense ground strata of the atmosphere. Even with the 3,200 feet per second velocity obtained by Sir Andrew Noble a surprising increase in range can be expected over the 12-mile Jubilee range when this extra allowance of tenuity is taken into account, and a range of 60 miles be almost attainable.

SOME TUNGSTEN ORES IN THE NATIONAL MUSEUM

For some years the department of geology in the United States National Museum has been making a special effort to build up its collections of the so-called rare earths and rare metals, many of which have assumed exceptional importance since the outbreak of the war. These collections include a considerable range of substances which have proved of commercial value only within the past decade, one of the most important of which is the metal tungsten, invaluable in steel manufacture. During the past year the department has received, principally through the intervention of Mr. F. L. Hess, of the U. S. Geological Survey, three most remarkable specimens illustrating the three types of ore of this metal. In its own way, each of the three is unique and undoubtedly the largest of its kind ever mined.

The first is a mass of ferberite (iron tungstate) from the No. 7 lease of the Vasco Mining Co., at Tungsten, Boulder County, Colorado, which was presented by the Vasco Mining Co., and Messrs. Stevens and Holland. The specimen is roughly oval in form, 2 feet

6 inches long, 2 feet broad, and 2 feet thick, and weighs nearly a ton. It is an ore characteristic of the Boulder tungsten field—a brecciated pegmatite and granite cemented by quartz and ferberite.

The second is a large specimen of the newly discovered mineral tungstenite (tungsten sulphide), a gift from Wm. Barrett Ridgely, of New York City. Tungstenite is a soft, lead-gray mineral, looking very much like fine-flaked molybdenite and carries some 44 per cent. tungsten. The specimen, which contains an admixture of some galena and quartz and weighs more than 100 pounds, is from the Emma mine at Alta, Utah. This mineral was identified only last December by R. C. Wells and B. S. Butler, of the United States Geological Survey, and almost simultaneously by K. D. Kuhre and Mr. J. J. Beeson, the geologist at the mine.

The third, and in some ways the most remarkable specimen, is a mass of scheelite (calcium tungstate) from the Union Mine of the Atolia Mining Co., Atolia, California. This mine is undoubtedly the richest and largest scheelite mine ever discovered, and the specimen is correspondingly large. It is a section across the main part of the vein and is 4 feet 8 inches long, about 2 feet 6 inches wide, and 2 feet thick. Some granodiorite, the country rock, is inclosed. The specimen weighs 2,600 pounds and carries possibly 30 per cent. WO_3, so that it contains in the neighborhood of 700 pounds of metallic tungsten and is worth, at the present price of ore, nearly $2,000. Great care was needed to remove the specimen from the mine intact, a work which was carried on under the supervision of Charles S. Taylor, one of the discoverers of the mine and now its superintendent.

CHEMISTRY AT YALE UNIVERSITY

IT has been arranged at Yale University to unite the staffs and laboratories of the undergraduate departments of the college and of the Sheffield Scientific School in a single department. On this plan the *Yale Alumni Weekly* comments as follows:

The article which we publish in this number on the coordination of chemistry teaching in the college and Sheffield marks a move in what we have good reason to believe will shortly become a general reorganization at the university on a new and cooperative departmental basis. Until now chemistry at Yale has been divided into two distinct and unrelated parts, with its two separate faculties and student groups, its two separate laboratories and equipments, its two separate financial systems, its two separate heads. It has furnished a striking instance of the historical cleavage between the Sheffield Scientific School and Yale College, with all the attendant lack of cooperation and sympathetic understanding which that cleavage has for so many years resulted in. If any criticism of Yale's educational organization has been unanswerable, for years it has been this continued separation between its two undergraduate schools in the teaching of common subjects. It has split Yale into two—on occasion even hostile—camps. It has hindered scientific progress in both schools. It has broken up at the start any possible unity of educational policy which might have been accomplished.

Until now it has seemed impossible to find a way to end this illogical and harmful cleavage between Sheff and the college in their educational organization. But the war, which is subtly undermining a good many of our ancient prejudices, both individual and institutional, has begun to play its deciding part in this historic Yale question. The hours of classroom exercises have recently been made to conform for the undergraduates of both Sheff and the college. The departments of chemistry have now found it necessary to reorganize to meet the new conditions, and, in reorganizing, have found it possible and even desirable to cut the old Gordian knot of departmental prejudices and consolidate as a university department. When this new plan goes into effect, Yale will have made its first definite move in what we believe will be a much more general trend in the near future, toward operating its educational machinery as one university organization rather than as two separated undergraduate departments.

In an article on the subject in the *Yale Alumni Weekly* Professors Bertram M. Boltwood and Treat B. Johnson mention as the greatest needs of the university in chemistry: (1) an adequate endowment for research, (2) the appointment of research professors in each department to organize and direct, (3) opportunities to give greater encouragement to our younger men to carry out research work, (4)

conditions tending to stimulate cooperation between manufacturing interests and our research laboratories in order to broaden as much as possible the applied features of our research work.

SCIENTIFIC NOTES AND NEWS

Director William Wallace Campbell, of the Lick Observatory, University of California, has been elected a foreign member of the Royal Society.

The annual gold medal of the British Institution of Naval Architects has been awarded to Professor G. W. Hovgaard, of the Massachusetts Institute of Technology, for his paper on "The Buoyancy and Stability of Submarines."

At the annual meeting of the Chemical Society, London, on March 21, the Longstaff medal for 1918 was presented to Lt.-Col. A. W. Crossley, for his work in the field of hydroaromatic compounds.

The University of Chicago has granted leave of absence to Professor Forest R. Moulton, of the department of astronomy and astrophysics, for one year, from April 1, 1918. He is commissioned major in the Ordnance Reserve Corps of the United States Army, and will have the duty of directing the computation of range tables and ballistic data.

Dr. T. Wingate Todd, F.R.S.C. professor of anatomy in the school of medicine of Western Reserve University, has been granted leave of absence from the university and commissioned captain in the Canadian Army Medical Corps. He is at present stationed at the Military Hospital of London, London, Ontario, and expects to see service in France within a few months.

Dr. Robert W. Hegner, of the University of Michigan, who has been carrying on research work at the Johns Hopkins University during the past year as Johnston scholar, has been reappointed and will continue his investigations there for another year.

T. B. Wood, professor of agriculture in the University of Cambridge, has been appointed to the Development Commission of Great Britain, vice A. D. Hall, now secretary of the Board of Agriculture and Fisheries.

Dr. Elbert C. Lathrop has resigned his position as biochemist in the Laboratory of Soil Fertility Investigations, U. S. Department of Agriculture, to accept a research position with the Jackson Laboratory of the E. I. du-Pont de Nemours Company, of Wilmington, Delaware.

Mr. R. C. Bergen, assistant editor of *Metallurgical and Chemical Engineering*, has resigned his position to go into manufacturing work. He has been with the journal since its change to a semi-monthly in 1915.

John C. Schelleng has resigned his instructorship in the department of physics of Cornell University to accept a position in war work with the Westinghouse Electric Company.

The course of lectures on "Symbolic logic" by Mrs. Christine Ladd-Franklin which was to have been given at Harvard University beginning on April 22, has been given up on account of the existing situation. These lectures were given earlier in the season at Columbia University before the Institute of Arts and Sciences.

Professor W. A. Cogshall, of Indiana University, delivered recently an address before the St. Louis Academy of Science on "The problems of the total solar eclipse with particular reference to the Corona and the intra-mercurial planets."

Professor E. V. McCollum, of the school of hygiene and public health of the Johns Hopkins University, delivered a lecture on nutrition, before the faculty and students of the college of medicine, University of Illinois, on April 11.

Dr. E. Emmet Reid, of Johns Hopkins University, delivered an illustrated lecture on "Gas warfare" before the West Virginia Scientific Society on April 15. In the afternoon of the same day, he addressed the students of chemistry of the university on "The present status of the chemist."

Dr. Winfred Berdell Mack, professor of veterinary science and bacteriology in the University of Nevada, died in Reno on January 18, after an illness of three months, aged forty-seven years.

Edwin Scott Linton, a member of the class of 1918, Johns Hopkins Medical School, and enlisted with the Johns Hopkins Hospital Unit, Base Hospital No. 18, A. E. F., died in France, of scarlet fever, on November 14, 1917. He was the son of Professor Edwin Linton, of Washington and Jefferson College.

Dr. S. M. Sandwith, of the London School of Tropical Medicine, died on February 16, at the age of sixty-four years.

Professor P. Blaserna, vice-president of the Senate, and professor of experimental physics in the University of Rome, died on February 26, at eighty-two years of age.

The agricultural appropriation bill, carrying a total of $28,000,000, has been passed by the Senate.

The Bureau of Standards has purchased eight acres of land west of Connecticut Avenue, Washington, D. C., and has let contracts for a new engineering laboratory, 175 by 350 feet, and four stories in height. The new building and its equipment will cost in the neighborhood of $1,000,000 and will increase the capacity of the bureau by 50 per cent. The Pittsburgh laboratory of the bureau, including the work on glass and ceramics, will be transferred to Washington. It is expected that the new building will be ready for occupancy during the coming summer.

The American Electrochemical Society has arranged in connection with its spring meeting in the week of April 28 for a tour through Tennessee and Alabama stopping at the important electrochemical centers and water power developments located in these two states. Among the towns to be visited are Johnson City, Kingsport, Knoxville, Sheffield, Muscle Shoals, Chattanooga, Anniston and Birmingham. A special train will be provided, and about one hundred members and guests have already signified their intention to participate. All those interested can obtain further details from Mr. Charles F. Roth, chairman of the committee, 50 East 41st St., New York City, N. Y.

The annual meeting of the New England Federation of Natural History Societies will be held on Friday and Saturday, April 26 and 27, at the Rogers Building, Boston, next house to the Society of Natural History. The usual exhibition will be open to members and visitors both days, and all the societies and individual members are invited to exhibit. Packages may be sent by express or left at the building in care of the janitor. Friday evening from 7 to 10 there will be an informal meeting for showing exhibits and for short reports and addresses. Members who can not attend on Saturday are specially invited to this meeting. Saturday, at 10 A.M. the annual meeting will be held for reports from the various societies and for the election of officers and other business. A short account of the last year's work of each society is desired at this meeting. A meeting of the council will be held immediately after the general session to examine the accounts, to decide on the admission of new members and to arrange for future meetings. Saturday afternoon the Boston Mycological Club will have its collections open to visitors from 1 to 5 at its room in the Horticultural Society's Building, 300 Massachusetts Avenue, corner of Huntington Avenue. The Brookline Bird Club will lead an observation walk in the Brookline Parkway, starting from the corner of Brookline Avenue and Audubon Road at 3 P.M.

The corporation of Yale University has voted to give annually the income from ten thousand dollars to the *American Journal of Science* to assist in the publication of this journal, which this year celebrates its one hundredth anniversary, and to which Professor Edward S. Dana has given so generously of his time and energy for many years.

The *Bollettino di Bibliografia e Storia delle Scienze Matematiche,* edited by Professor Gino Loria, of Genoa, which has been of such value to mathematicians interested in the bibliography and history of their subject, is about to begin a new series. It will appear in improved form from the press of the well-known scientific publisher, D. Capozzi, of Palermo.

The *Journal* of the American Medical Asso-

ciation reports that some statistics have recently been published showing that of the 345 medical and other scientific journals published in France before the war, about 270 have suspended publication. Others have changed from weekly to a monthly issue and others issue only four numbers a year. The total quantity of the paper used by them now does not amount to more than 35 tons a month. The important discoveries and experiences of the war and the lessons from them have been spread broadcast by the medical journals, so that surgeons and physicians have been able to keep abreast of progress and thousands of lives have been saved. The organization medical press in France is pleading with the authorities for special concessions during the period of the prevailing scarcity of paper, but no heed has been paid to the appeal as yet.

UNIVERSITY AND EDUCATIONAL NEWS

Yale University has received from the Kingsley Trust Association (Scroll and Key Society of Yale College) $30,000 to commemorate the seventy-fifth anniversary last year of the founding of the society. This is to be added to the endowment of the Kingsley Trust Association Publication Fund, established by the members of the Society in 1914, and will increase the total of this to $50,000; making it the largest publication fund held by the university. The income of the original $20,000 is used for publications through the Yale University Press in the field of history.

The Massachusetts State College is requesting a state appropriation of $100,000 for the development of women's work at the institution, $70,000 being for a women's building and $30,000 for maintenance until November 30, 1920.

In response to a request from the gun production of the Ordnance Department, United States army, the school of applied science of New York University has put its testing laboratory at the service of the government.

Thomas P. Cooper, director of station and extension work in North Dakota, has been appointed dean of the Kentucky College of Agriculture and director of the Experiment Station.

Dr. H. G. Knight, dean of the college of agriculture and director of the experiment station of the University of Wyoming, has accepted the corresponding position at the Oklahoma College and Station, effective February 1, and has been succeeded at Wyoming by A. D. Faville.

Professor Harvey Evert Huber, professor of biology and geology at Ohio Northern University since 1913, has resigned to accept the professorship of biology at Bluffton College. He will assume his new position in September.

L. T. Anderegg, in charge of the department of chemistry in the high school at Decatur, Ill., has accepted the position at the Kansas State Agricultural College in chemical analysis which was left vacant by the resignation of R. C. Wiley.

Dr. Gerald L. Wendt has been appointed assistant professor of chemistry and curator of the Kent chemical laboratory at the University of Chicago. He has charge of the instruction in quantitative analysis and in radioactivity.

Lina Stern, privatdozent in the University of Geneva, has been appointed professor extraordinary of physiological chemistry.

DISCUSSION AND CORRESPONDENCE

SPECTROSCOPIC INVESTIGATION

To the Editor of Science: An exceptional opportunity for spectroscopic investigation now exists in this country and it seems desirable that it should have the wide publicity of the columns of Science. The Mining Experiment Station at Golden, Colorado, under the Federal Bureau of Mines, specializes in the radium products and the rare gases which are associated with their production. It is likely that larger quantities of the radium emanation, for instance, are available there for research than anywhere else in the world at the present time.

A visit to this interesting laboratory last autumn disclosed the presence there of a large

Hilger spectrograph of the autocolimating type, with very large prisms, and apparently capable of yielding excellent spectra on a large scale. The members of the regular staff of chemists at the Station, under the direction of Dr. R. B. Moore, are too much occupied with their regular duties to undertake special spectroscopic researches. Therefore this fine instrument has not been utilized as it might be. An unusual chance is thus presented for the establishment of a fellowship for spectroscopic research, under the joint auspices of the station and of some university, physical laboratory or scientific fund.

A second consideration of immediate importance lies in the fact that Golden is situated near the central line of the total eclipse of June 8. American science could be accused of grievous neglect, if this spectrograph, already in the eclipse track, should not be used on that occasion by an expert spectroscopist. To many such I have written personally during recent months, urging that the opportunity be improved; but as a result of war duties or the shortage of assistants in the laboratories, thus far no one has been found who could undertake the work.

It would be necessary for the person to go to Golden early enough in May, so that the spectrograph could be put into excellent adjustment and then to mount it where a clear view of the northwestern sky could be had. The necessary heliostat could doubtless be borrowed from some laboratory. The altitude of Golden is 5,700 feet, and if the foliage around the station building was too heavy in June, it would not be at all difficult to transport the spectrograph up to an elevation of about 7,500 feet on Lookout Mountain, where Colonel Cody was buried.

The ideal arrangement will of course be for this same person who gets familiar with this spectrograph to continue in research with it after the eclipse. If a suitable person is found, an effort can be made to raise the necessary funds for a fellowship or other basis which may be arranged for the work.

Time might perhaps be saved for those who may wish to consider the observation of the eclipse with this instrument, if they will write to me directly.

I am writing this at the request of Dr. Charles L. Parsons, of the Bureau of Mines, and Dr. Moore.

Edwin B. Frost

Yerkes Observatory,
Williams Bay, Wisconsin,
April 13, 1918

THE DESICCATION OF THE EARTH

To the Editor of Science: In Notes on Meteorology and Climatology in the issue of Science for October 21, 1910, attention is invited to an article in *Umschau* by Dr. Karl Stoeckel which helps to explain the slow desiccation of the earth.

> It is believed that the ultra-violet rays of sunlight which fall upon the water vapor suspended in the lower strata of the earth's atmosphere decompose a small part of it to produce hydrogen, which rises to great heights. . . .

I do not think it has been pointed out before that the earth's surface must be continuously losing hydrogen through the decomposition of water vapor by every flash of lightning. Pickering and others have recognized the hydrogen lines in the spectrum of lightning, and the larger works on meteorology mention the fact that lightning flashes decompose some water. See Hann's "Lehrbuch der Meteorologie," 2d edition, page 480:

> But the electric flash also decomposes some water and causes the incandescence of the hydrogen.

The hydrogen formed by every lightning flash rises rapidly to the upper atmosphere and is lost to the earth.

Considering the frequency of thunderstorms during the summer season in both hemispheres and at all times in the equatorial regions the loss of hydrogen in this way can not be considered as insignificant. As long as conditions upon the earth remain such as to render thunderstorms possible, the slow desiccation of the earth must continue.

C. F. von Herrmann

AREAS OF AUDIBILITY

To the Editor of Science: Students of the constitution of the atmosphere have published

very interesting results as a consequence of the investigation of areas of audibility and *inaudibility* surrounding great sources of sound, such as the blasting for the Jungfraubahn, the bombardment of Antwerp, a munition explosion in England, etc. It seems natural that the Halifax explosion, violent enough to break glass many miles distant and to be heard scores of miles away at sea, should be investigated the same way; but I have read and heard nothing of any such study. It is, of course, a matter for the scientists of the neighboring region, and perhaps they have taken it up.

Willard J. Fisher

PRIMITIVE KNOWLEDGE OF INOCULATION

In an article on "The Origin of the Custom of Tea Drinking in China," Science, March 15, R. A. Gortner remarks that "it is extremely improbable that it was recognized centuries ago that typhoid fevers, etc., were disseminated by pollution of the water supply, especially inasmuch as there was no knowledge of microorganisms or of the rôle which they play in disease until the work of Pasteur (1857–1863)." In adopting this conclusion as *a priori* valid it seems to me that Gortner is in danger of making the same error that was made by Sir Richard Burton in 1854. Burton states ("First Footsteps in East Africa") that "The mosquito bites bring on, according to the same authority (the Somal), deadly fevers; the superstition probably arises from the fact that mosquitoes and fevers become formidable about the same time." This is not the only case, we may be sure, in which causal relations have been recognized long before the causal mechanism was known.

Knight Dunlap

SCIENTIFIC BOOKS

The Anthocyanin Pigments of Plants. By Muriel Wheldale. Cambridge University Press. 1916. Royal 8vo. Pp. xii + 318. Price 15s net.

The science of chemistry has grown so rapidly during recent years that it is impossible for an individual to acquire a thorough knowledge of all of its branches, and even to master a single phase of the science often means laborious searchings through the chemical literature. Fortunately there have appeared during the last decade a number of monographs, each written by an authority in that particular field, which deal thoroughly with a special topic and sum up all of the available literature. Such a compilation is the present volume.

What causes the production of the colors in a flower? Every one has asked himself the question and numerous chemists have attacked the problem, yet it is only within recent years that any definite knowledge has been attained and we still have a long way to progress before we know the whole truth. It is fortunate, however, that Miss Wheldale has accumulated such evidence as is at present available.

Her studies of anthocyanin began with a study of the genetical behavior of these pigments, but she soon ascertained that biological phenomena have for their basis chemical reactions, with the result that she undertook to analyze the chemical changes which were involved in the hereditary behavior of flower coloration. The present volume is divided into two parts. Under Part I., "General Account of Anthocyanins," we have "Introductory," consisting mainly of the older literature of the subject; "The Morphological Distribution of Anthocyanins"; "The Histological Distribution of Anthocyanins"; "The Properties and Reactions of Anthocyanins"; "The Isolation and Constitution of Anthocyanins"; "Physiological Conditions and Factors Influencing the Formation of Anthocyanins"; "Reactions Involved in the Formation of Anthocyanins"; and "The Significance of Anthocyanins," practically all of which are taken up from the chemical viewpoint.

Under Part II., "Anthocyanin and Genetics," we find "Classes of Variation"; "Details of Cases of Mendelian Inheritance in Color Varieties"; "Connection of Flower Color with the Presence of Anthocyanin Vegetative Organs, Fruits and Seeds"; "Heterozygous Forms"; "Color Factors in Reduplication

Series"; "Pattern in Color Variation"; "Striped Varieties and Bud Variation"; "The Effect of Outside Factors on Color Variation"; "Connection Between Color and Other Plant Characters"; and "The Chemical Interpretation of Factors for Flower Color;" all discussed from the standpoint of the geneticist. In addition there is appended a bibliography of 645 titles, to the majority of which Miss Wheldale has added a short descriptive notice indicating the nature of the contents of the paper.

To any one who has followed Miss Wheldale's researches it is needless to add that the work is thoroughly done. Apparently as much space has been given to the papers of her critics as to her own work, so that the reader can draw his own conclusions as to the facts involved. If there is any one fault to find with the work it would seem to the writer to be that the author has not drawn upon her imagination sufficiently to formulate theories which would appear to be warranted by the facts which she presents. This is not a common fault in works of this nature where chemical and biological phenomena are involved and perhaps the author is correct in being extremely conservative. At any rate she can not be accused of attempting, by publishing this monograph, to further any pet hypothesis.

ROSS AIKEN GORTNER

UNIVERSITY OF MINNESOTA

DR. KEEN ON MEDICAL RESEARCH

DR. W. W. KEEN, the Nestor of the American medical profession, has given us a delightful little book on "Medical Research and Human Welfare," being the Colver Lectures of Brown University for 1917.

Dr. Keen is peculiarly fitted for his task, as he was trained in the old septic era of surgery before the civil war, and was a part and parcel of the war with all its attendant horrors, its infections and gangrenous wounds with maggots, and its enormous percentage mortality, and yet has lived not only to witness but to promote the new era of antiseptics and to enjoy the phenomenal changes thus wrought in his own work and that of his colleagues.

This interesting little book has a twofold value, it will attract the lay public asking for a conspectus of the progress of the last forty years in charming readable non-technical terms; it will also interest doctors, who will enjoy a brief historic retrospect of professional achievements told in just such simple terms as they themselves are apt to use over a fireside conversation when the older men are prone to indulge in reminiscences and comparisons.

A further use is to furnish material for those who wish to forestall interference on the part of the anti-research people (who call themselves "antivivisectionists"), with medical progress.

The medical profession in our day has stepped forward into an era of medical statesmanship, and now needs constantly to appeal to the public for moral support and cooperation in many matters of vital interest to the whole body politic. It would be well for this reason if this book were widely read and the facts kept well in mind and often used in arousing the sympathy of the public in one of the greatest of all causes—medical progress, the saving of life and health.

HOWARD A. KELLY

THE ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES

THE program of the scientific sessions of the meeting held in Washington beginning on April 22 was as follows:

MONDAY, APRIL 22

Morning Session

The effects of a prolonged reduced diet on twenty-five college men:

I. On basal metabolism and nitrogen excretion, by Francis G. Benedict.

II. On neuromuscular processes and mental condition (illustrated), by Walter R. Miles (introduced by F. G. Benedict).

III. On efficiency during muscular work and general muscular condition (motion pictures), by H. Monmouth Smith (introduced by F. G. Benedict).

The partial occlusion of great arteries in man and animals (illustrated), by W. S. Halsted.

Three papers (illustrated):

(*a*) The favorable effect of subcutaneous injec-

tion of magnesium sulphate in tetanus; (*b*) the possible danger of intravenous injection of magnesium sulphate; (*c*) The antagonistic and curative action of calcium salts in these cases, by S. J. Meltzer.

The Liberty field hospital ward. Designed on the unit construction plan. Portable. Adapted to American overseas summer and winter service (motion pictures), by Henry Fairfield Osborn.

The war and medical research (illustrated), by Simon Flexner.

Afternoon Session

Conformal geometry, by Edward Kasner.

Magnestism by rotation (illustrated), by S. J. Barnett (by invitation. Comstock prize recipient).

On the correction of optical surfaces, by A. A. Michelson.

Some recent observations of the brighter nebulæ (illustrated), by W. W. Campbell.

Physical researches for the war, by R. A. Millikan.

Evening Session

First William Ellery Hale Lecture, by John C. Merriam, professor of paleontology, University of California. Subject: The beginnings of human history from the geologic record. (Open to the public.)

TUESDAY, APRIL 23

Morning Session

Notes on isotopic lead, by F. W. Clarke.

The physico-chemical properties of gluten, by Lawrence J. Henderson (introduced by Raymond Pearl).

Correlation of the tertiary formations of the southeastern United States, Central America and the West Indies, by Thomas Wayland Vaughan (introduced by David White).

Coast survey charts and fringing reefs of the Philippine Islands (illustrated), by W. M. Davis.

Recent researches on the skeletal adaptations and modes of locomotion of the Sauropod Dinosaurs (illustrated), by Henry Fairfield Osborn and William K. Gregory.

Some additional data on the Cambrian Trilobites (illustrated), by Charles D. Walcott.

The development of governmental regulations during the world war, by C. R. Van Hise.

Afternoon Session

The big bears of North America, by C. Hart Merriam.

The growth of the Pribilof fur-seal herd between 1912 and 1917 (illustrated), by G. H. Parker.

A comparison of the growth changes in the nervous system of the rat with the corresponding changes in man (illustrated), by Henry H. Donaldson.

Measuring the mental strength of an army (illustrated), by Robert M. Yerkes (by invitation).

Second William Ellery Hale Lecture, by John C. Merriam, professor of paleontology, University of California. Subject: The beginnings of human history from the geologic record.

SPECIAL ARTICLES

A SIMPLE METHOD OF MEASURING PHOTOSYNTHESIS[1]

In collaboration with Loeb[2] one of us observed that certain marine algæ when exposed to sunlight cause the sea water to become more alkaline. Similar observations had been previously made by others[3] upon fresh-water plants in solutions containing bicarbonates.

It seemed to the writers that this procedure might be utilized in the study of photosynthesis. After investigating a number of marine plants it was found that *Ulva* (sea lettuce) is very satisfactory for such experiments. A piece of *Ulva* was placed in a beaker and covered with sea water to which a little phenolphthalein[4] had been added. It was then placed in direct sunlight. In the course of an hour the solution turned pink. The pink color grew steadily more pronounced and at the end of another hour was intense.

It seemed evident that by measuring the alkalinity which produced the change of color we might arrive at a simple and satisfactory method of studying photosynthesis.

In order to measure the degree of alkalinity produced by *Ulva,* a piece of the frond was placed in a tube of Pyrex glass[5] (about 12 mm. in diameter) in such a manner that it com-

[1] Preliminary communication.

[2] Loeb, J., "Dynamics of Living Matter," 1906, p. 98.

[3] *Cf.* Czapek, F., "Biochemie der Pflanzen," 1913, 1: 519.

[4] Ten drops of saturated alcoholic phenolphthalein was added to 1 liter of sea water. For class demonstration more may be added.

[5] This glass was chosen because it does not give off measurable quantities of alkali during the period of the experiment.

pletely covered the inside of the tube for the greater portion of its length. Fronds were chosen which were sufficiently stiff so that their own elasticity caused them to remain closely and evenly pressed against the inner surface of the glass tube even when liquid was poured in and out or shaken back and fourth in the tube.

The glass tube was sealed off at one end, while at the other it was furnished with a short piece of rubber covered with paraffin.[6] The covering of paraffin was continuous and care was taken to renew it each time the tube was used.

After placing the frond in the tube, the latter was filled with sea water (at the temperature of the bath) and the rubber tube was clamped shut. In some cases a small bubble of air was left in the tube to act as a stirrer: in other cases the tube was completely filled with sea water and the stirring was effected by a small piece of paraffin or by a glass bead covered with paraffin.

The tube was then placed in a large water bath in direct sunlight. The tube was slanted so as to receive the sunlight nearly at right angles. The light passed through a sufficient amount of water to filter out most of the heat rays. Some light was reflected from the surface of the water but this was practically constant during any one experiment. The temperature of the bath was kept constant within 1° in most of the experiments.

In order to determine the degree of alkalinity produced by photosynthesis two methods were used. In the first the indicator was added to the sea water containing *Ulva* after a definite exposure to sunlight; in the second the indicator was added to the sea water before the exposure began. In the latter case there was a possibility that the presence of the indicator might affect the amount of photosynthesis, but it was found by control experiments that this was not the case with the concentrations employed in these experiments.

It was also necessary to ascertain whether the degree of alkalinity produced was a reliable measure of the amount of photosynthesis. This was done by making simultaneous determinations of the degree of alkalinity and the amount of oxygen evolved (by Winkler's method). The results show that the amount of photosynthesis, as indicated by the evolution of oxygen, is approximately a linear function (in this range) of the change in the PH value of the sea water. This being so we can measure the amount of photosynthesis by determining the change in PH value regardless of any possible complications such excretion of alkali by the plant.

Since the plants produce CO_2 by respiration this must be taken into consideration. Experiments conducted under precisely the same conditions except that light was excluded showed that the respiration was practically constant. It is, therefore, easy to make a correction for it.

In order to ascertain how much photosynthesis had taken place after a definite time the pink color produced by the *Ulva* was matched against the colors of a series of tubes (of the same size) containing the same concentration of indicator in a series of buffer solutions of known alkalinity.[7] The matching was done under a "Daylight" lamp, which is invaluable for this purpose.

In this way the degree of alkalinity produced may be easily ascertained and since this corresponds to the amount of oxygen evolved it gives us a direct measure of photosynthesis, provided we know the amount of CO_2 or of O_2 corresponding to the observed changes in alkalinity. These may be determined in various ways which can not be discussed here.

[6] It is necessary to use paraffin which will not give off measurable quantities of acid during the time of the experiment. For this purpose paraffin of a high melting point is usually advantageous. Rubber should be used which gives off the minimum amount of acid; the rubber used in these experiments was repeatedly boiled before using.

[7] For buffer solutions see: Sörensen, *Biochem. Zeit.*, 21: 131, 1909; *Ergeb. d. Physiol.*, 12: 392, 1912. Höber, R., *Physik. Chem. d. Zelle u. d. Gewebe*, 4te Aufl., 1914, S. 169. Bayliss, W. M., "Principles of General Physiology," 1915, p. 203.

For the PH values needed in these investigations mixtures of .05 *M* borax and 0.2 *M* boric acid (to each liter of boric acid 2.925 gm. NaCl is added) are useful. The following table gives the

In order to study the effects of temperature, light intensity, etc., it is not necessary to know the amount of CO_2 abstracted; it is sufficient to compare the time required to produce the same change in the color of the indicator under different conditions. This gives much more accurate results than comparison of the amounts of CO_2 abstracted in equal times. In case anything is added to the solution which changes its buffer value due allowance must be made for this.

It is evident that the method is accurate, simple, rapid and convenient, permitting us to measure minute amounts of photosynthesis at frequent intervals.

It may be added that aquatic plants are greatly to be preferred to land plants for quantitative studies of photosynthesis because in the latter the temperature can not be satisfactorily controlled while with the former the fluctuations can be confined within one degree, or less.

PH values of a series of mixtures (Palitzsch, S., *Bioch. Zeit.*, 70: 333, 1915. *Compt. rend. lab. Carlsberg*, 11: 199, 1916). *Cf.* McClendon, J. F., Gault, C. C., Mulholland, S., Pub. 251 Carnegie Inst., 1917, pp. 21-69.

0.2 *M* Boric Acid, c.c.	.05 *M* Borax, c.c.	PH
0	10	9.24
1.0	9.0	9.11
2.0	8.0	8.98
3.0	7.0	8.84
4.0	6.0	8.69
4.5	5.5	8.60
5.0	5.0	8.51
5.5	4.5	8.41
6.0	4.0	8.31
6.5	3.5	8.20
7.0	3.0	8.08
7.5	2.5	7.94
7.7	2.3	7.88
8.0	2.0	7.78
8.5	1.5	7.60
9.0	1.0	7.36
9.4	0.6	7.09
9.7	0.3	6.77

By plotting the c.c. of borax as ordinates and the PH values as abscissae a curve is obtained from which intermediate values can be obtained by graphic interpolation.

From the PH values found in sea water 0.21 must be subtracted on account of the "salt error."

Similar experiments were made with a variety of fresh-water plants, including *Spirogyra, Hydrodictyon* and *Potamogeton.* The results were very satisfactory. The usual procedure was as follows: A gallon bottle was filled with the water in which the plants were growing, a little phenolphthalein was added and a solution of sodium bicarbonate was then added, drop by drop, until a pink color was produced.[8] On pouring this into the tubes used in the experiments the pink color was not perceptible since the layer of liquid was not sufficiently thick.

When the algæ were placed in these tubes in sunlight a pink color appeared in a short time. If the tubes were placed in the dark the color disappeared as the result of respiration. In many cases the algæ lived for several days in these tubes and made considerable growth, showing that they were not injured.

The method is well adapted to class work. For ordinary laboratory demonstrations Pyrex glass is not necessary since any good glass[9] will answer. It will be found that some algæ (particularly blue-green and unicellular green algæ) will operate satisfactorily in diffused daylight. It is important, however, that the plants be in active condition. Aquatics are apt to prove unsatisfactory in fall and winter while in spring and summer the same species may be very active.

SUMMARY

Minute amounts of photosynthesis can be accurately measured by placing aquatic plants in solutions containing bicarbonates, with a little phenolphthalein, and observing changes in the color of the indicator.

The convenience, simplicity and rapidity of the method make it as useful for class-room demonstration as for quantitative investigations.

W. J. V. Osterhout,
A. R. C. Haas
Laboratory of Plant Physiology,
Harvard University

[8] This solution should be freshly made each day.

[9] Open bottles, test-tubes, beakers or tumblers may be employed.